Announcements

- Homework for tomorrow…

  Ch. 30: CQ 6, Probs. 10, 14, & 16

  29.26: $U_C(t) = (1.1 \times 10^{-3}\ t^2)$ J for $0 < t < 3$s

  $U_C(t) = (1.0 \times 10^{-2})$ J for $3\text{s} < t < 4\text{s}$

  29.29: a) $U_C = 1.1 \times 10^{-7}$ J b) $u_E = 0.71$ N/m^2

  29.60: 20 μF

- Office hours…

  MW 10-11 am

  TR 9-10 am

  F 12-1 pm

- Tutorial Learning Center (TLC) hours:

  MTWR 8-6 pm

  F 8-11 am, 2-5 pm

  Su 1-5 pm

Chapter 30

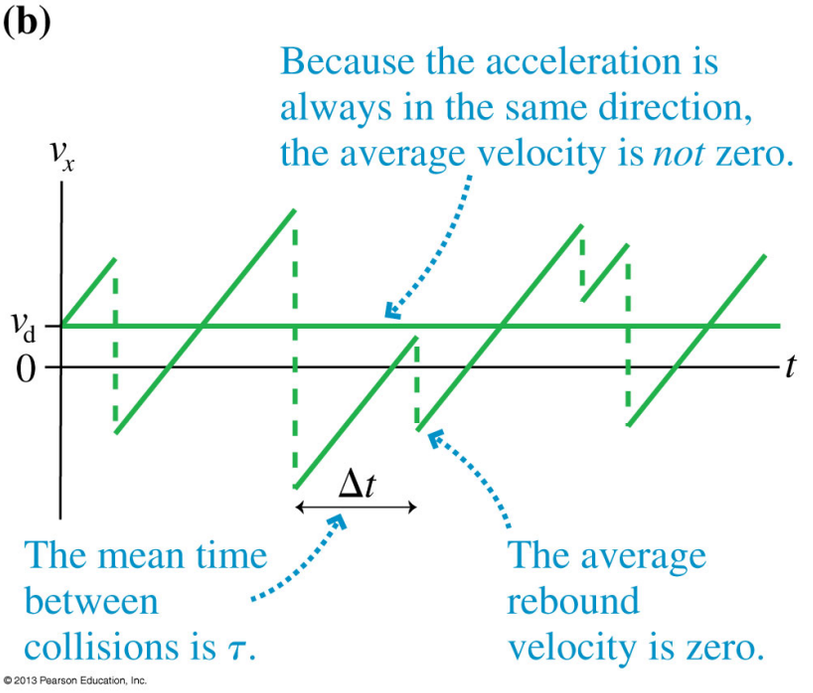
Current & Resistance

(*Current and Current Density & Conductivity and Resistivity*)

A Model of Conduction

Q: If there is a *non-zero E*-field, then there is a *non-zero F*, so shouldn't my electrons accelerate?

- instead of move at a *constant drift velocity*, v_d?



A Model of Conduction

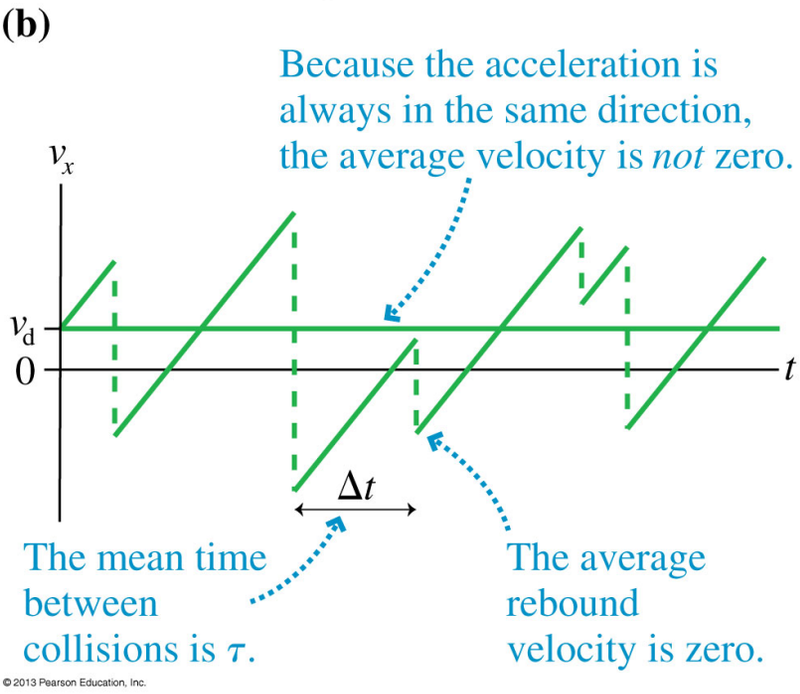
Q: If there is a *non-zero E*-field, then there is a *non-zero F*, so shouldn't my electrons accelerate?

- instead of move at a *constant drift velocity*, v_d?

$$v_d = \frac{e\tau}{m}E$$

so the electron current is..

$$i_e = \frac{n_e e\tau A}{m}E$$



i.e. 30.3: Collisions in a copper wire

i.e. 30.1 found the electron current to be 2.6×10^{19} s^{-1} for a 2.0 mm diameter copper wire in which the electron drift speed is 1.0×10^{-4} m/s.

If an internal *E*-field of 0.020 V/m is needed to sustain this current, how many collisions per second, on average, do electrons in copper undergo?

30.3: Current and Current Density

Define the *current*...

$$I \equiv \frac{dQ}{dt}$$

For a *steady current*...

$$I = \frac{\Delta Q}{\Delta t}$$

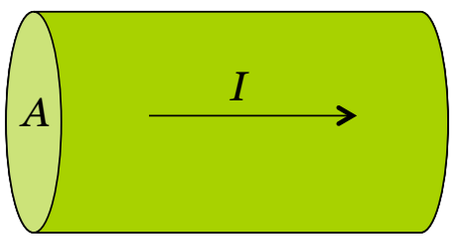
SI Units?

$$[I] = \frac{C}{s} \equiv A$$

Amperes or "amps"

30.3:
Current and Current Density

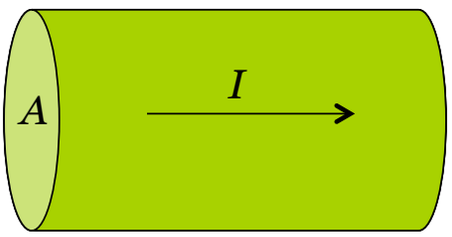
So, how is the *current* related to the *electron current?*



30.3: Current and Current Density

So, how is the *current* related to the *electron current?*

$$I = ei_e$$



Notice:

The direction of the current is *defined* to be the direction in which positive charges *seem* to move.

i.e. 30.4: The current in a copper wire

The electron current in the copper wire of i.e.'s 30.1 and 30.3 was 2.7×10^{19} electrons/s.

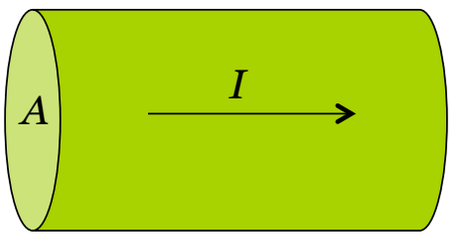
What is the current I?

How much charge flows through a cross section of the wire each hour?

30.3: Current and Current Density

Define the *current density*...

$$J \equiv \frac{I}{A}$$



SI Units?

$$[J] = \frac{A}{m^2}$$

30.3: Current and Current Density

The *current density* in a wire…

$$J \equiv \frac{I}{A} = \eta_e e v_d$$

i.e. 30.5: Finding the electron drift speed

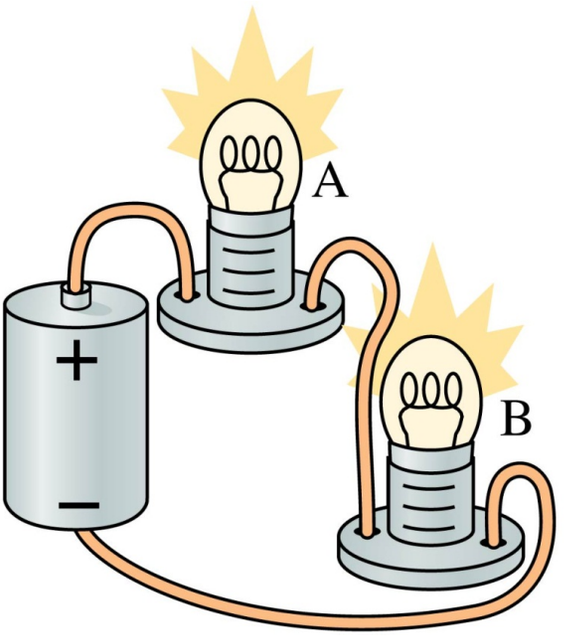
A 1.0 A current passes through a 1.0 mm diameter aluminum wire.

What are the current density and the drift speed of the electrons in the wire?

Quiz Question 1

A and B are identical light bulbs connected to a battery as shown.

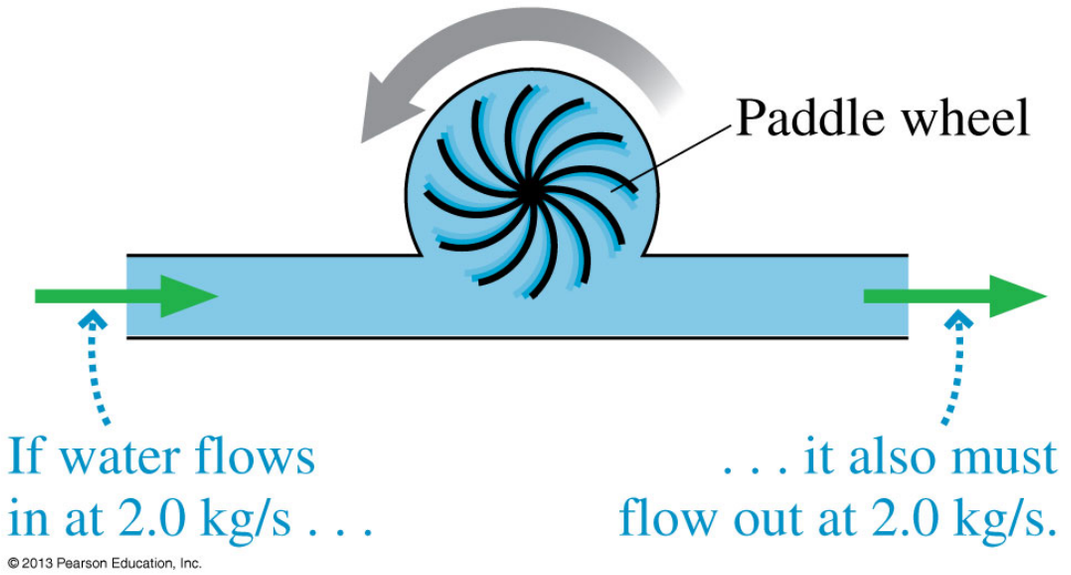
Which is brighter?



1. Bulb A.
2. Bulb B.
3. The bulbs are equally bright.

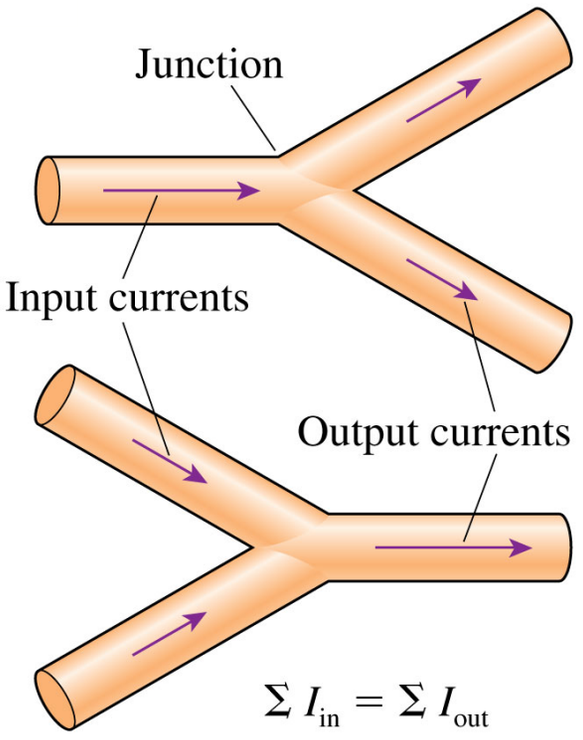
Conservation of Current

H_2O Pipe Analogy:



Conservation of Current

- The rate of electrons leaving a light bulbs is *exactly the same* as the rate of electrons entering the light bulb.
- The current does NOT change!

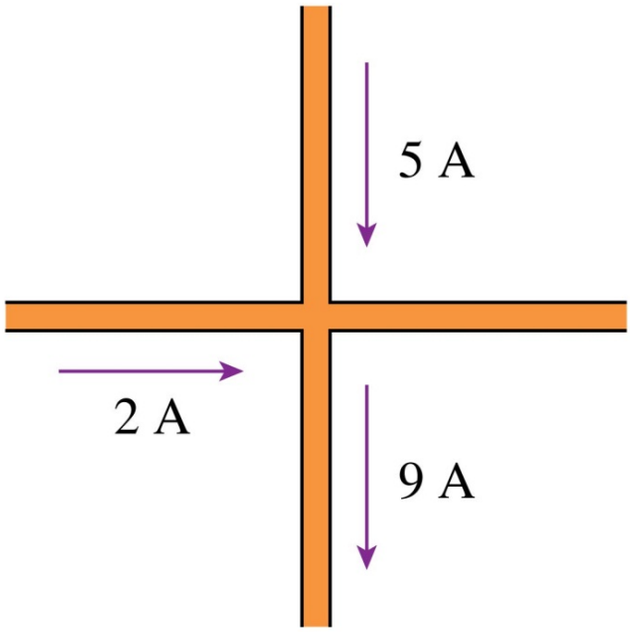


Kirchoff's Junction Rule

$$\sum I_{in} = \sum I_{out}$$

Quiz Question 2

The current in the fourth wire is



1. 16 A to the right.
2. 4 A to the left.
3. 2 A to the right.
4. 2 A to the left.
5. Not enough information to tell.

30.4: Conductivity and Resistivity

How is the current density, J, related to the E-field driving the current?

30.4: Conductivity and Resistivity

How is the current density, *J*, related to the *E*-field driving the current?

$$J = \sigma E$$

where $\sigma = \dfrac{n_e e^2 \tau}{m} =$ conductivity

30.4: Conductivity and Resistivity

How the current density, J, is related to the E-field driving the current:

$$J = \sigma E$$

Notice:

1. *Current* is caused by the E-field exerting forces on the charge carriers.
2. The *current density* (& *current*) depend *linearly* on the *strength* of the E-field.
3. The *current density* also depends on the *conductivity* of the material.